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THE GROUND WATER PROGRAM FOR PENNSYLVANIA

COMMONWEALTH OF PENNSYLVANIA
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GENEVIEVE BLATT, *Secretary*
TOPOGRAPHIC AND GEOLOGIC SURVEY
CARLYLE GRAY, *State Geologist*

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THE GROUND WATER PROGRAM FOR PENNSYLVANIA

PURPOSE OF THE PROGRAM

The objectives of the ground water program in Pennsylvania are to evaluate and appraise the occurrence, availability, and quality of the ground water resources of the Commonwealth, and to determine the most effective methods for their conservation and development.

These objectives can be accomplished only by systematic, detailed investigations of the geologic and hydrologic conditions under which ground water occurs in Pennsylvania, and of the effects on the natural system of certain human activities such as withdrawing water from wells, underground disposal of wastes, and diversion or pollution of natural recharge. These investigations must include the following: Geologic studies to determine the location, extent, thickness, and anomalous characteristics of the aquifers (water-bearing formations); hydrologic and geophysical studies to determine the hydraulic properties of the aquifers, the sources and quantities of recharge to the aquifer, the direction and rate of movement of the ground water, areas of discharge and rates of discharge from the aquifer. Studies must be made to determine the significant chemical and physical characteristics of the ground water, in order to relate the quality of water to the aquifer in which it occurs, and to determine the effects of human activities on the quality of water. As the water-bearing strata are buried beneath the land surface, most pertinent data must be obtained by indirect methods such as electric logging and related borehole geophysical techniques, microscopic examination of drill cuttings, and pumping tests.

Comprehensive ground-water investigations are generally costly and prolonged efforts that seldom end in a final product because the dynamic influences of human activities must be continually reevaluated against the more static geologic and hydrologic controls.

HISTORY OF THE PROGRAM 1925-59

The major part of the continuing program of ground-water studies in Pennsylvania has been supported by cooperation between the Commonwealth and the Federal Government.

Ground-water investigations began in Pennsylvania in 1925 under a cooperative agreement between the Pennsylvania Geological Survey and the Ground Water Branch of the United States Geological Survey. The agreement continued to 1943, by which time all parts of the State had been covered by reconnaissance studies which were described in six area reports and one state-wide report published by the Pennsylvania Geological Survey. In 1930, a state-wide network of observation wells was established designed to determine the long-term trends of ground-water levels in rural areas largely unaffected by local withdrawals from wells. This study has been kept current, and the results have been published annually in reports of the United States Geological Survey.

The cooperative program was expanded in 1943 to provide for more intensive local studies, chiefly on a county-wide basis. To date, descriptive-type reports have been published by the State Survey for Allegheny, Beaver, and Bucks counties, and studies of local problem areas have been completed for the Triangle district in downtown Pittsburgh, the Philadelphia Naval Base in Philadelphia, and the Lansdale area in Montgomery County. Three other reports are in manuscript: one describes the occurrence of ground water in the Stockton Formation in Montgomery and Bucks counties, one describes the ground-water resources of the Coastal Plain sediments in Philadelphia and Bucks counties, and the other is a discussion of the brines in Pennsylvania – a study carried out in cooperation with the Regional Industrial Development Corporation of Pittsburgh, Pennsylvania. Studies are well advanced in Lehigh, Lawrence, and Mercer counties. Concurrent with these investigations, the United States Geological Survey Ground Water Branch, in its position as advisor to the State Geologist and to Federal agencies on ground-water supply problems, has conducted numerous short-term local studies, the results of which are described in various memoranda and draft-copy reports.

In addition to Federal appropriations to the cooperative investigations, the Federal Government has also financed several water-utilization studies and one special research project in Pennsylvania. The water-utilization studies include a state-wide appraisal of water use in Pennsylvania, and compilation-type reports for Pittsburgh, Erie, and southeastern Bucks County, all of which were published as U. S. Geological Survey Circulars. The research project is a detailed study of mining hydrology. The results of this study will ultimately be published in a report of the U. S. Geological Survey.

Following is a bibliography of the reports prepared under the Pennsylvania ground-water program. The areas covered by the individual project studies are shown in Figure 1.

Piper, Arthur M., Ground water in southwestern Pennsylvania, Pa. Geol. Surv., 4th series, Bull. W 1, 1933.

Hall, George M., Ground water in southeastern Pennsylvania, Pa. Geol. Surv., 4th series, Bull. W 2, 1934.

Leggette, R. M., Ground water in northwestern Pennsylvania, Pa. Geol. Surv., 4th series, Bull. W 3, 1936.

Lohman, Stanley W., Ground water in northeastern Pennsylvania, Pa. Geol. Surv., 4th series, Bull. W 4, 1937.

Lohman, Stanley W., Ground water in south-central Pennsylvania, Pa. Geol. Surv., 4th series, Bull. W 5, 1938.

Lohman, Stanley W., Ground water in north-central Pennsylvania, Pa. Geol. Surv., 4th series, Bull. W 6, 1939.

Lohman, Stanley W., Ground-water resources of Pennsylvania, Pa. Geol. Surv., 4th series, Bull. W 7, 1941.

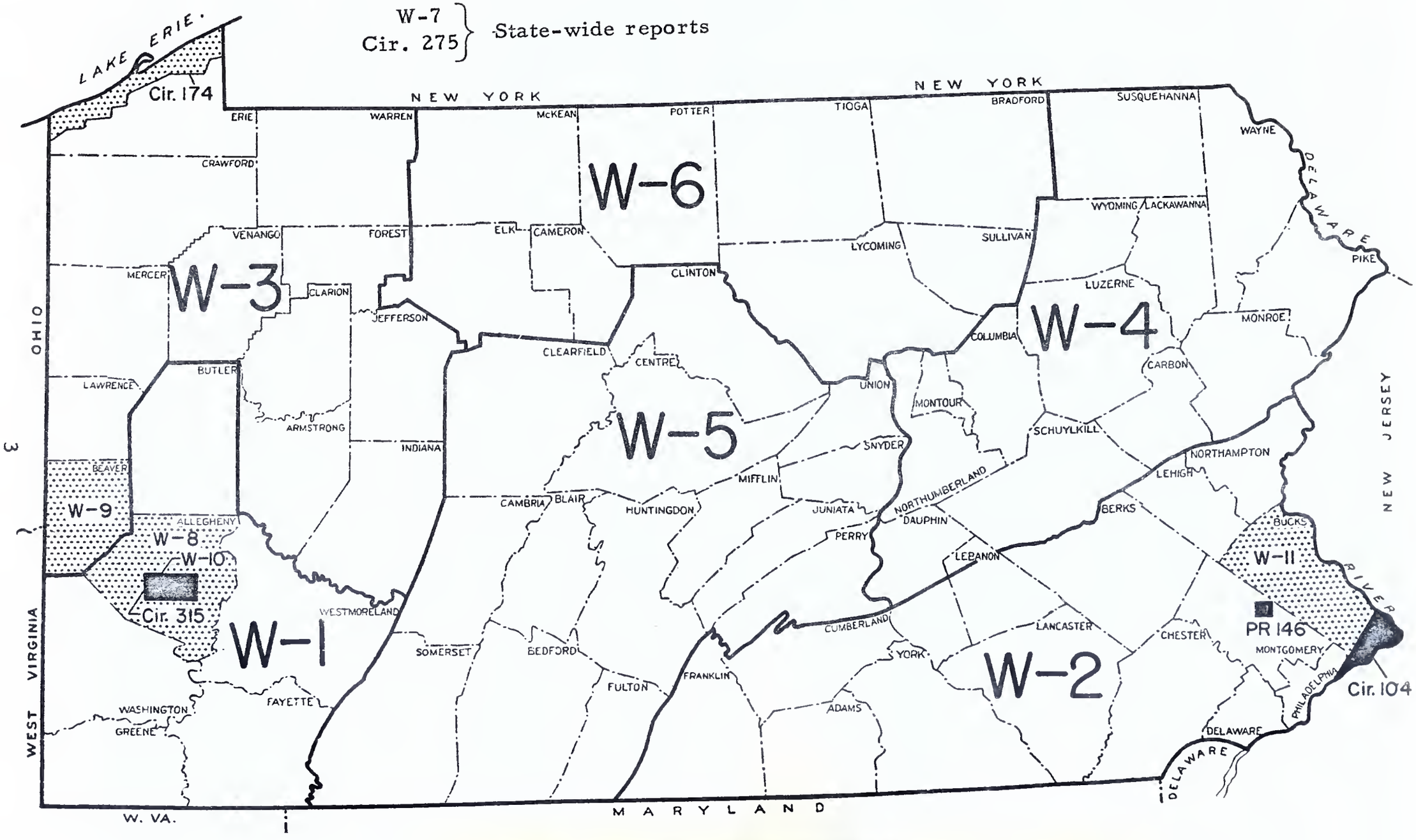


Figure 1. Map showing areas in Pennsylvania covered by ground-water reports.

Adamson, J. H., Jr., Graham, J. B., and Klein, N. H., Ground-water resources of the Valley-Fill deposits of Allegheny County, Pennsylvania. Pa. Geol. Surv., 4th series, Bull. W 8, 1949.

Van Tuyl, D. W., and Klein, N. H., Ground-water resources of Beaver County, Pennsylvania, Pa. Geol. Surv., 4th series, Bull. W 9, 1951.

Van Tuyl, D. W., Ground water for air conditioning at Pittsburgh, Pennsylvania, Pa. Geol. Surv., 4th series, Bull. W 10, 1951.

Greenman, David W., Ground-water resources of Bucks County, Pennsylvania, Pa. Geol. Surv., 4th series, Bull. W 11, 1955.

Rima, Donald R., Ground-water resources of the Lansdale area, Pennsylvania, Pa. Geol. Surv., 4th series, Progress Report 146, 1955.

Graham, J. B., Mangan, J. W., and White, W. F., Jr., Water resources of southeastern Bucks County, Pennsylvania, U. S. Geol. Surv. Circ. 104, 1951.

Mangan, J. W., Van Tuyl, D. W., and White, W. F., Jr., Water resources of the Lake Erie shore region in Pennsylvania, U. S. Geol. Surv. Circ. 174, 1952.

Mangan, J. W., and Graham, J. B., The use of water in Pennsylvania, 1951, U. S. Geol. Surv. Circ. 257, 1953.

Noecker, Max, Greenman, D. W., and Beamer, N. H., Water resources of the Pittsburgh area, Pennsylvania, U. S. Geol. Surv. Circ. 315, 1954.

Barksdale, H. C., Greenman, D. W., Lang, S. M., Hilton, G. S., and Outlaw, D. E., Ground-water resources of the Tri-State Region adjacent to the lower Delaware River, Special Report 13, New Jersey Division of Water Policy and Supply, Trenton, 1958.

NEED FOR FURTHER STUDIES

Ground-water investigations are needed in Pennsylvania to provide a basis for dealing with problems that have already arisen, and to provide a design for the future orderly exploitation of the ground-water resources of the Commonwealth. It should not be concluded that any investigative program, however detailed, would provide a solution for all current and future problems of ground-water supply. But many problems can be mitigated or averted, and others can be anticipated and hence preceded by adequate plans and preparations.

The problem of ground-water supply in Pennsylvania is not one of total available supply, because properly conserved and distributed, there is sufficient water to supply the greatest expansion of population and industry that can be anticipated.

The principal problems are local in nature – of determining the available dependable supply, and then protecting that supply from over-development and pollution.

Quantitative information is needed in Pennsylvania: How deep does ground water normally occur in various types of rocks; how much water can be anticipated from a properly located and constructed well; how far apart should wells be drilled for maximum efficiency. Pump tests, in which a well is pumped while careful measurements are taken on water levels in surrounding wells, can supply much of this information. Electric well logs will be used to determine the nature of the concealed strata. These logs show the electrical properties of rocks; shale has different electrical properties from sandstone, and different patterns are obtained in logging the two types of rock. Therefore, much information can be gained which is of vital importance to the geologic and hydrologic interpretation of an area.

The last state-wide survey of water use in Pennsylvania was made in 1951. At that time the use of ground water in Pennsylvania amounted to over one-half billion gallons per day with the largest withdrawals concentrated in the industrial areas of Pittsburgh and Philadelphia. The distribution and utilization of the withdrawals for use are shown in Figure 2. These figures do not include the vast quantities of water that are pumped by mines and quarries – such pumpage probably equals or exceeds the withdrawals for direct use. It is certain that the demand for ground water will increase greatly in the coming few years. Growing communities, and new and expanding industries will require ever-increasing supplies. Perhaps the largest increase in use will occur in the rural areas as more and more farmers take advantage of cheap electrical power to supply automatic water systems, modern sanitary facilities in their homes, and irrigation systems in their fields.

The availability of ground water to supply present and future needs is determined firstly by the occurrence and character of the fresh water-bearing beds, and secondly by the extent to which the natural conditions have been impaired by the actions of man. The natural conditions are very complex. Pennsylvania is underlain by a wide variety of rock formations ranging from crystalline rocks of Precambrian age to unconsolidated deposits of Cretaceous and Quaternary ages. The rocks differ greatly in their thickness and areal extent, composition, texture, geologic structure, and topographic expression; all of these factors influence their capacity to store and transmit water. Furthermore, these same factors show great variations within individual formations so the regional problems of locating and identifying water-bearing beds are commonly no more complex than the local problems. These factors divide the state into four ground water provinces, within each of which the ground water conditions are essentially similar (Figure 3).

In the Piedmont and the Valley and Ridge areas the rocks have been altered in texture, or folded and faulted to expose the beveled edge of the strata at land surface, so the character of the rocks is seldom uniform throughout any large area. The similarity between these regions ends with structure, since radically different rock-types and topography are present in each. In the Plateau areas of western and northeastern Pennsylvania, the rocks are generally flat-lying and have extensive areas of outcrop, but they are deeply dissected by stream valleys, and the individual beds vary markedly in thickness and lithology, commonly grading from sandstone to shale and back to sandstone within a distance of a few hundred feet. The Pleistocene

EXPLANATION

.04 - million gallon per day - Public Supply
1.0 - " " " " - Industrial Supply
2.6 - " " " " - Rural Use
A - less than 0.1 million gpd.

Total Use

over 50 million gpd
20-50 " "
5-20 " "
2-5 " "

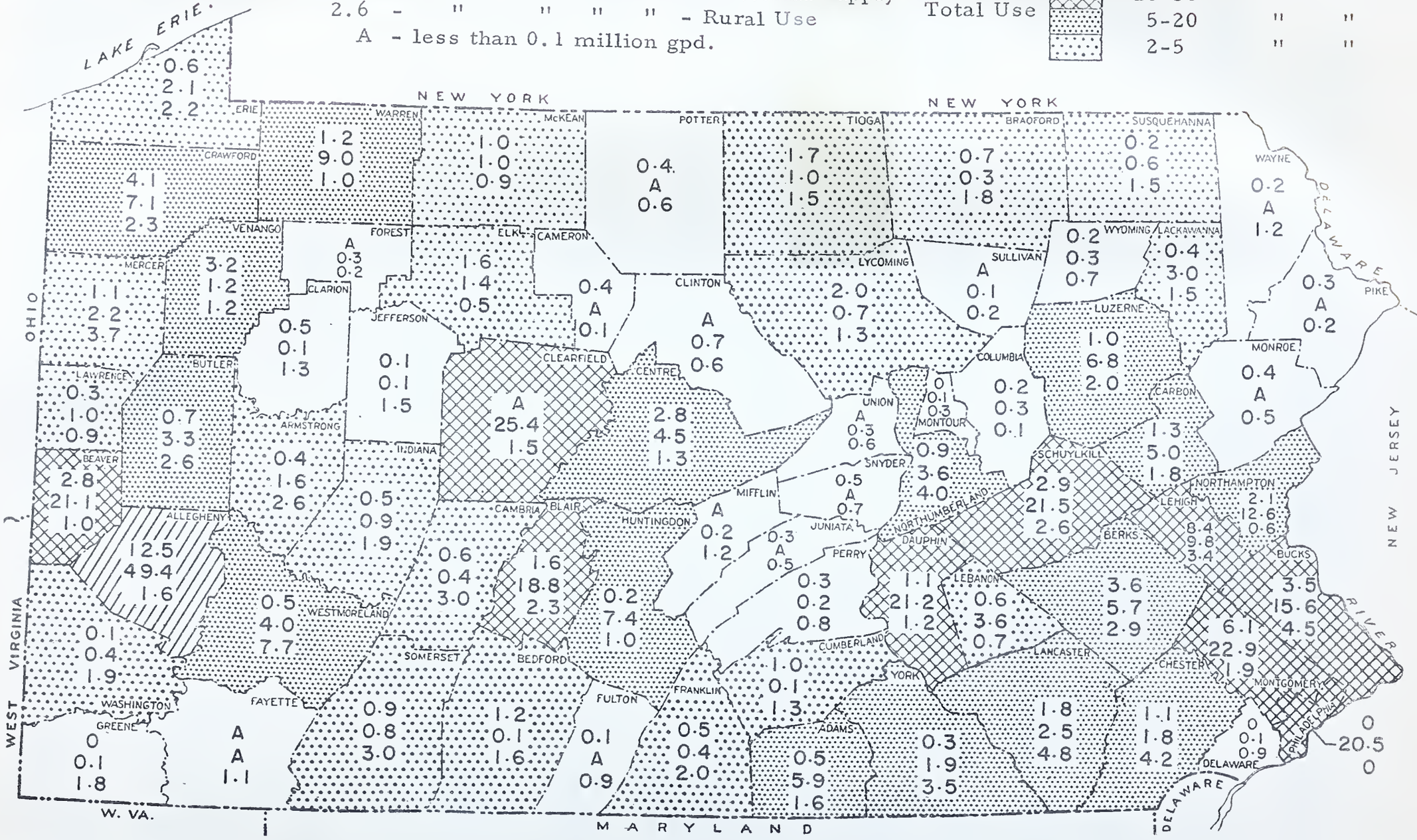
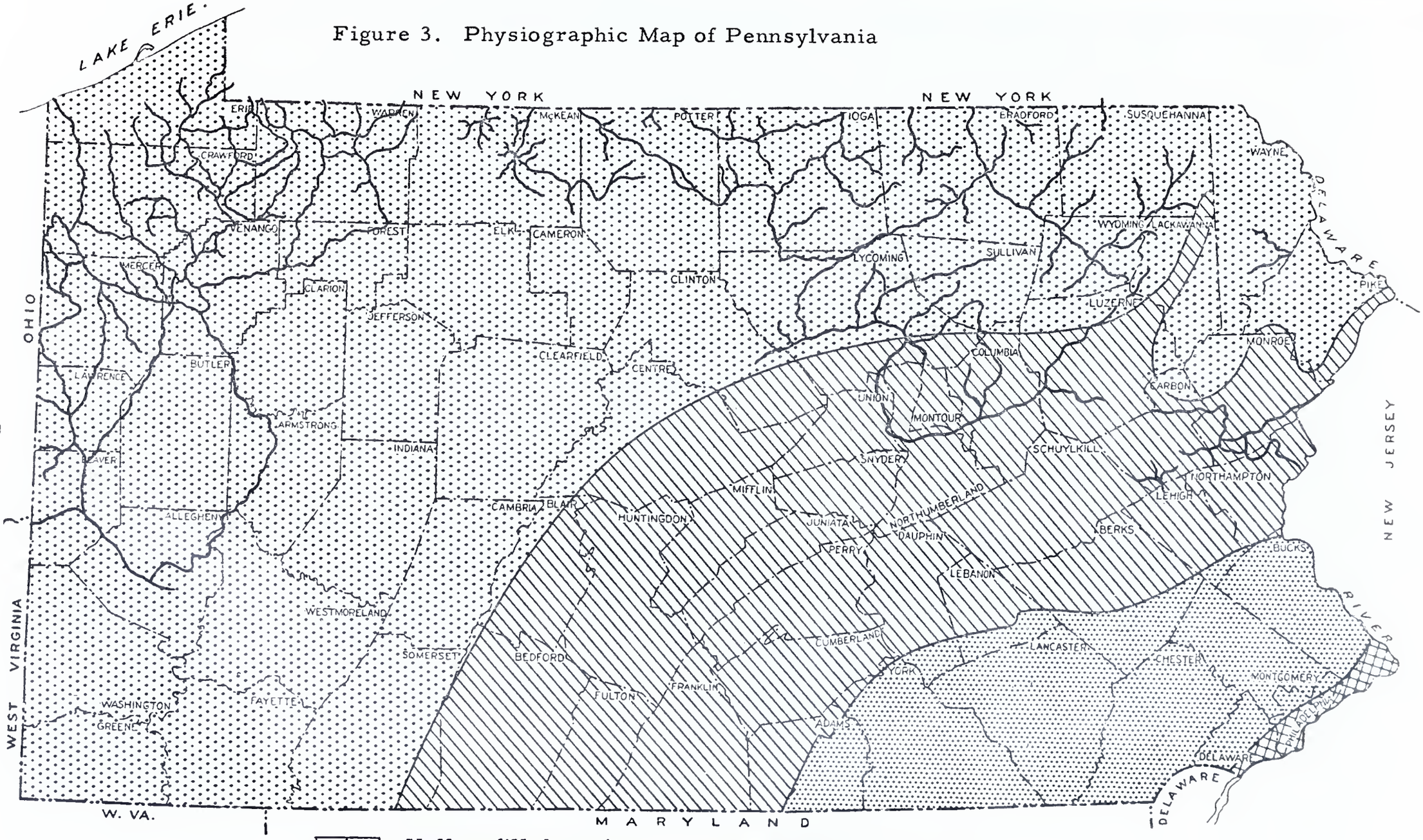


Figure 2. Map showing ground water use in Pennsylvania

Figure 3. Physiographic Map of Pennsylvania



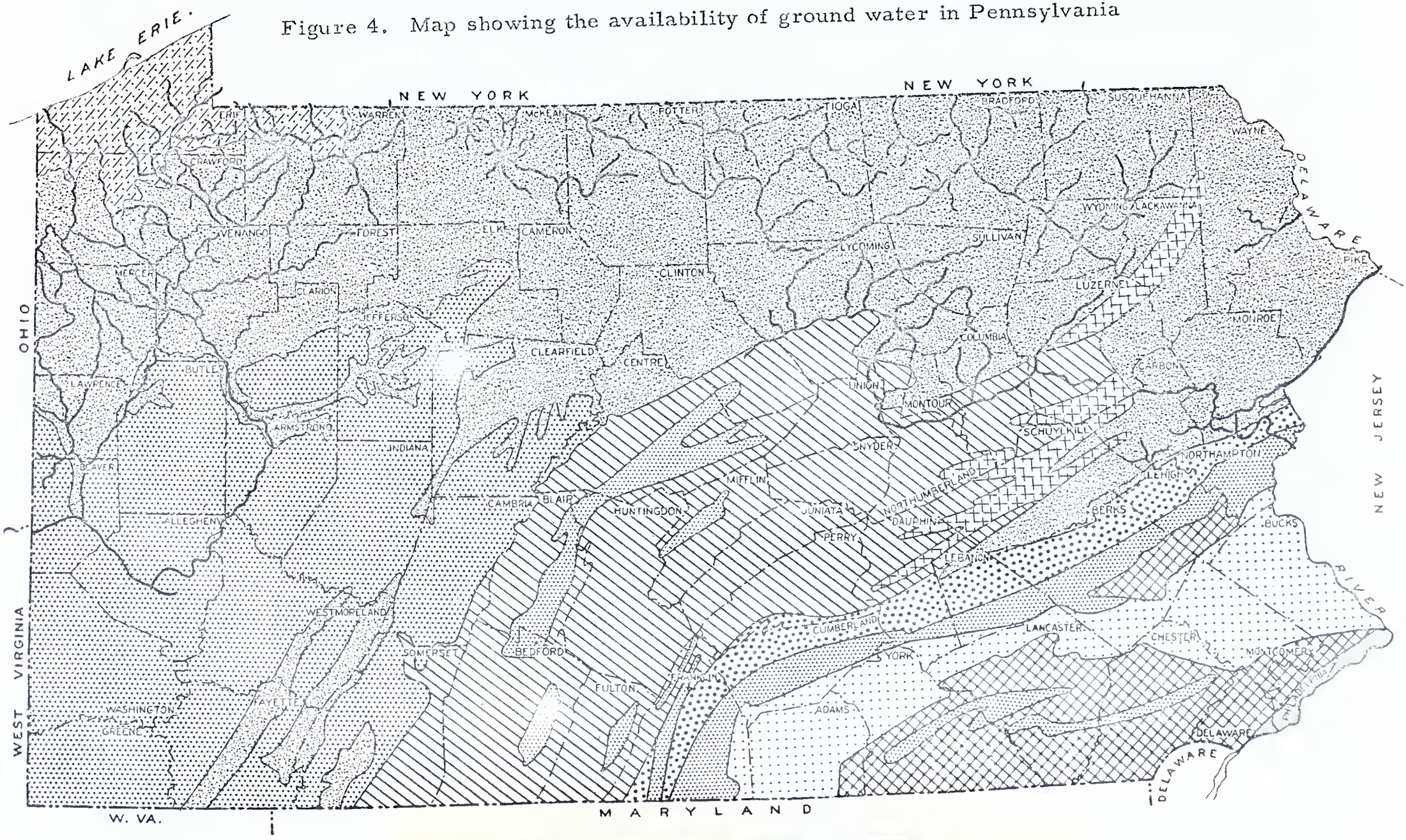
valley-fill deposits and the Coastal Plain sediments are even more irregularly deposited and chaotically interbedded and it is seldom possible to trace the water-bearing sands and gravels from one borehole to another. Thus, throughout Pennsylvania the natural ground-water conditions vary so markedly from place to place that the availability of water at a given site generally cannot be reliably predicted solely on the basis of yields of near-by wells.

The effects of human activities are superimposed upon the natural anonalies of ground-water occurrence. As a result so-called "problem areas" occasionally develop. Rarely do "problem areas" occur as a direct result of withdrawals of ground water for use; they commonly occur as a consequence of some unrelated activity. Only in local areas in Pittsburgh, Philadelphia, and a few other communities do present withdrawals appear to approach the practicable yield of the aquifers. But even in those areas, other factors are usually involved. For example, in the Triangle area of downtown Pittsburgh, sheet piling was driven to a depth of 40 feet along the bank of the Allegheny River thereby sealing much of the aquifer from river recharge. In the Philadelphia area the availability of ground water from the unconsolidated deposits poses less of a problem than the quality of water which has progressively deteriorated in recent years largely as a result of pollution of sources of recharge by sewers, disposal wells, and refuse dumps.

Other serious problems of ground-water supply occur in the bituminous coal fields of western Pennsylvania and in the anthracite fields of central and northeastern Pennsylvania. In those areas the most favorable aquifers have been drained or polluted with acid water as a result of the mining activity. Similar problems, but on a more local scale, occur in the limestone valleys of central and southeastern Pennsylvania, except that the pollutants are generally derived from industrial and domestic disposal systems. Quality of water problems also occur locally in the oil and gas fields of northcentral and western Pennsylvania due largely to upward migration of salt water through abandoned boreholes.

The availability of fresh ground water in Pennsylvania is shown on Figure 4. It is apparent that, despite the natural and artificial limitations on the supply, present ground water use is only a small fraction of the total available resources. It is the joint responsibility of the Commonwealth and its political subdivisions to protect present supplies and to insure the wise conservation and development of the total resources. The Federal Government shares this interest, particularly with regard to aquifers that cross state boundaries, and also has the responsibility of protecting a federal investment of over one billion dollars in real property in Pennsylvania, over half of which is invested in 92 military installations, most of which obtain their water supply from wells. The state and federal interests have combined in the studies to date, which are described above, and are partners in the current investigative program in Pennsylvania.

Figure 4. Map showing the availability of ground water in Pennsylvania



EXPLANATION FOR FIGURE 4

Pattern #	Lithology	Range in Yield (9 gpm)	Average Yield (9 gpm)	Chemical Quality	Remarks
1	Crystalline igneous and metamorphic rocks	5-100	15	Good, soft	Some water hard and high in Fe.
2	Limestone	5-1000	50	Good, hard	Source of many springs.
3	Shale	5-100	40	Good, moderately hard	Some water slightly high in Fe.
4	Shale, sandstone, and limestone	2-500	25	Good soft to very hard	Tonoloway and Helderberg limestones have largest yields. Water from some shales contains H_2S and Fe. Wills Creek Shale has up to 2000 gpm $CaSO_4$.
5	Sand, gravel, clay	small - mod.	20	Good	Water salty locally
6	Shale, sandstone, and limestone	v. small - large	75	Good, soft to mod. hard	Water of better quality in eastern Pennsylvania
7	Shale, sandstone, and limestone	25-300	50	Good, except near mines	Locally acidic hard, high in Fe. Monongahela Fm. high in $NaHCO_3$ at depth
8	Shale, sandstone, gravel, conglomerate	0-1000	10	Good, except near mines	Locally acidic hard, high in Fe.
9	Sandstone, shale, diabase	5-300	50	Generally hard	Diabase, where fractured, yields small amounts of soft water. Highest yields from Stockton Sandstone.
10	Sand	1-800	500	Soft to moderately hard	High in Fe and Mn in some places. Dissolved solids increase with pumping.
11	Sand and gravel	up to several thousand	large	Good, soft to hard	Locally hard and high in Fe in northcentral and northwestern Pennsylvania.

PROGRAM FOR CURRENT AND FUTURE GROUND WATER STUDIES IN PENNSYLVANIA

The current program consists of four types of investigations:

1. State-wide water-level study.

This is essentially a continuation of the program that was begun in 1930. Under the current program the observation-well network will be expanded to provide more comprehensive and representative coverage of the State. The water-level program will be implemented with a mobile force of automatic recorders which will be installed at most sites for a period of time sufficient to define the pattern or trend of the fluctuations, after which periodic tape measurements will be made.

2. Aquifer studies.

The major share of the cooperative ground-water program is devoted to systematic detailed studies of the hydrology of the important aquifers that occur in Pennsylvania. This phase of the program is essentially basic research, designed both to meet the need for quantitative definition of the occurrence, availability, and quality of ground water in Pennsylvania; and to obtain the development and application of new and improved methods and techniques with which to investigate ground-water conditions.

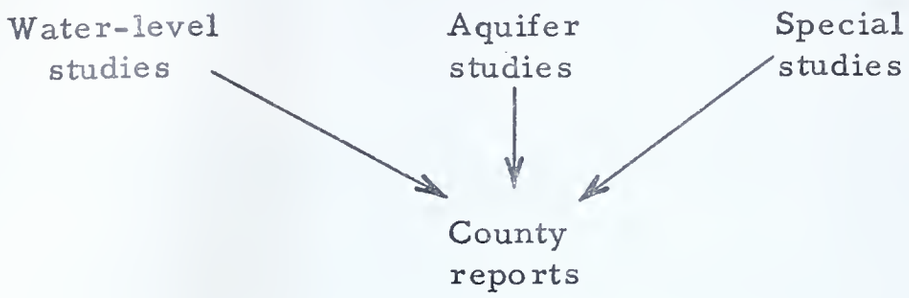
The aquifer studies are a departure from previous investigative programs in that the primary units of study will have natural hydrologic boundaries rather than artificial political boundaries, as was the case with the County Report series. County reports will remain a part of the program, but they will be prepared as by-products of the other phases of the program.

Aquifer units offer definite advantages for orderly and systematic investigation. The field personnel can concentrate on the specific problems related to the aquifer under study; furthermore, they will have more and better opportunities to study both regional characteristics of the aquifer and local anomalous conditions if they can operate over the full extent of the aquifer instead of being confined to its occurrence within a county. Another advantage of the aquifer studies is that the Pennsylvania Geological Survey's mapping program in southeastern Pennsylvania is largely based on geologic units that coincide with hydrologic units. Thus, most ground-water studies in southeastern Pennsylvania will be benefited with a detailed geologic map and reliable information on the lithology, stratigraphy, and structure.

The aquifer studies will be scheduled to provide more or less simultaneous investigation of all of the aquifers in a given area. In that way, complete and systematic coverage is assured for political subdivisions as well as for the ground-water provinces.

3. County reports.

County reports will continue to be the ultimate products of the ground-water program in Pennsylvania, but they will be derived as by-products or end-products of the basic studies according to the diagram below.



4. Special studies.

This category includes research studies financed under the Federal program, and special studies made for various state or federal agencies. The current program includes one research investigation into mining hydrology.

CURRENT PROJECTS

The current ground-water program in Pennsylvania includes five projects which are listed below. The locations of the projects are shown on Figure 5.

1. Annual water-level project. – The continuing study of trends and patterns of water levels in the entire State.

2. Ground-water hydrology of the Triassic sediments of southeastern Pennsylvania. – A detailed study of the occurrence and availability of ground water in the Triassic rocks; special emphasis will be placed on the use of borehole geophysical methods to describe and correlate the local and regional stratigraphy, structure, and hydrology.

3. Ground-water resources of the Pottsville Formation and associated aquifers in northwestern Pennsylvania. – A comprehensive study of the stratigraphic controls on the occurrence of ground water in the lower Pennsylvanian and upper Mississippian sediments in the western parts of the Allegheny Drainage Basin; primary objective is to describe in detail the occurrence of the highly productive sandstone members that constitute the most valuable undeveloped ground-water supplies in the Commonwealth.

4. Hydrology of limestones with special reference to the Great Valley of southeastern Pennsylvania. – A research study designed to describe the occurrence of ground water in the Cambro-Ordovician limestones with particular reference to relating the availability of ground water to the local structure and stratigraphy. This is a continuing study and will ultimately be expanded to include the Chester Valley in southeastern Pennsylvania and the limestone valleys in central Pennsylvania.

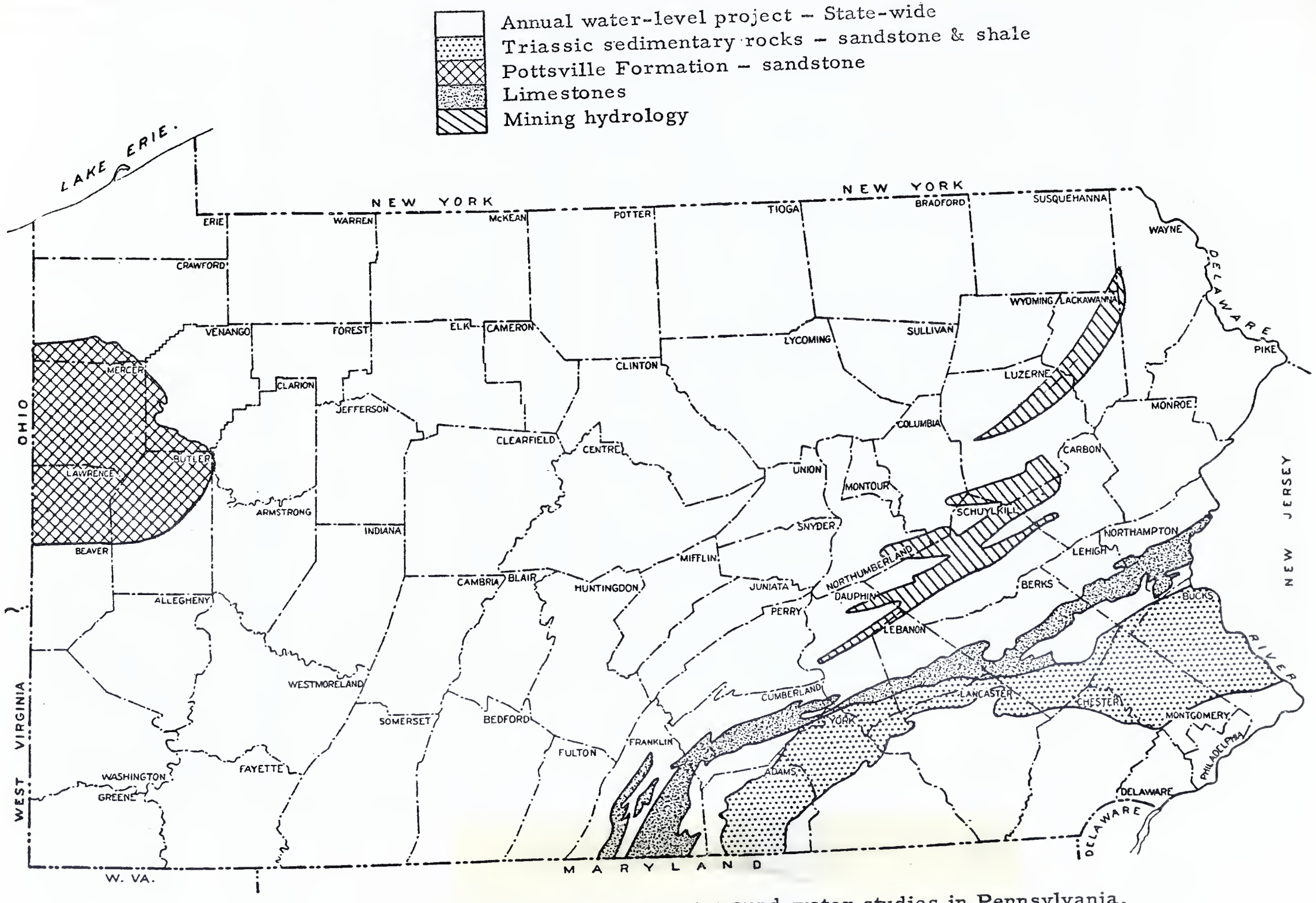


Figure 5. Map showing location of current ground-water studies in Pennsylvania.

5. Mining hydrology project. – A Federal research project designed to test the application of advanced hydraulic methods to the solution of dewatering problems encountered in mining operations.

The active program outlined above will be supplemented in the near future by three additional aquifer studies: the occurrence of ground water in the Precambrian crystalline rocks of southeastern Pennsylvania, the ground-water resources of the Pleistocene Valley-Fill deposits in the Allegheny Drainage Basin, and the geology and hydrology of the Martinsburg shale. With this assemblage of projects an investigative program will be established that will provide complete coverage of the important industrial and agricultural regions of southeastern Pennsylvania; and a start will be made in describing the undeveloped ground-water resources of northwestern Pennsylvania. County reports will be prepared as a routine part of the program whenever sufficient data are available.

FUTURE PROJECTS

As the various projects are completed, manpower will be available to begin other studies. The methods of study and the scheduling of future projects will be determined in part by experience with the current program. However, according to present plans and needs, the probable order of priority for future studies to complete the detailed coverage of the State is as follows:

1. The remaining lower Pennsylvanian and Mississippian beds in the Plateau region of western Pennsylvania.

2. The Pleistocene Valley-Fill sediments in the Schuylkill and Delaware Drainage Basins.

3. The Carboniferous rocks in the Plateau region of southwestern Pennsylvania.

4. The Devonian rocks in the Plateau region of northern and eastern Pennsylvania.

5. The folded rock in the Ridge and Valley Province of central and northeastern Pennsylvania.

6. The Devonian rocks in extreme northwestern Pennsylvania.

It should be recognized that this schedule is highly speculative and the order of priority may be changed considerably to meet unanticipated needs.

The progress and success of this program is dependent upon a number of factors, but chiefly upon the availability of funds and personnel. The current rate of progress is not commensurate with the immediate needs, not to mention future requirements for information on ground-water supply. The disparity is recognized by the Commonwealth. The cooperative program has more than doubled since 1953, and there should be further expansion of the cooperative program to meet the future commitments as described herein.